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Enhancing Information Fusion Using Spatial Auditory Displays and Videogame Interfaces

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The future of military operations will center on Network Centric Warfare (NCW). NCW is a rapidly evolving area for the modern military and borrows its philosophy and much of its technology from computer networks. Ultimately, all intelligence information collected by the military will be immediately available to planners and will require strategists, operators, and even warfighters on the ground to rapidly comprehend and integrate massive amounts of real-time, multi-dimensional data. Already, information from intelligence sources, satellites, unmanned aerial vehicles, and other assets are shared between military services which have their own unique ways of presenting and interpreting data sets. As the amount of data inevitably increases, the problem associated with using the data will increase. Most modern systems rely primarily on the visual displays which quickly overwhelm the visual channel. The challenges of NCW require the utilization of new display technologies and an unorthodox examination of techniques used in other industries, such as the entertainment industry. The goal in our laboratory has been aimed at measuring performance using advanced auditory displays and entertainment industry techniques with NCW types of tasks.

First, we have been assessing human performance using advanced audio display techniques to enhance communications in Command and Control scenarios. Although, the current discussion centers on spatial audio displays, we have also initiated a program to explore the newer "Audio Spotlight" technologies. We have also measured improvements in situational awareness for air-traffic control and unmanned aerial vehicle type scenarios using spatial auditory cues. Finally, we have recently initiated a project to measure possible performance enhancements of multi-modal interfaces combining tactile and spatial audio cues for use in aviation systems and are considering this technology as a possible way to convey multi-dimensional data to warfighters on the ground.

Our second research thrust has focused on adopting entertainment industry techniques to improve situational awareness in NCW Command Center scenarios. The Moves Institute

has been at the forefront of utilizing entertainment industry techniques with the creation of *America's Army: Operations* which was developed entirely in-house and has become a major videogame title in public use. In addition to evaluating technologies and ideas from industry leaders like Dolby, Creative Labs, Skywalker Sound, and the videogame industry, we have been performing partial task analyses of off-the-shelf game technologies to determine whether innovative techniques used in interface design for modern videogames can be implemented to improve performance in a real-time operational display system. Many current networked videogames require the same types of manipulation of complex data required in Network Centric Warfare implementations, yet military displays concepts have remained relatively static over time.

The following summarizes research in our laboratory that has been completed:

1. Spatial Audio Research

The idea for using spatial audio technology in communications is not new. However, many of the spatial audio speech recognition studies conducted in the past did not represent how communications occur in real-world environments. Many used multiple speaker-based presentations rather than headphone-based spatial audio systems. We attempted to create an experiment that combined the best aspects of rigorous controls yet maintained external validity using headphone-based spatial audio. To do this, participants were required to listen to simulated aircraft radio messages (360 different messages) which were presented simultaneously. The four communications channels were placed at 45, 135, 225 & 315 degrees around the participant's head. Participants were presented with either three or four simultaneous messages presented in an aviation message format. Participants were required to listen for their "call sign" which would be presented randomly in one of the three or four intervals. They were then required to extract the information content from their "target" message. Results indicated that participants accurately identified 43% of the messages in the spatialized condition, but only 17% of the messages in the non-spatialized condition. Chi-squared tests indicated a dependent relationship between accuracy and spatialization under a variety of conditions. The logit regression model confirmed these conclusions and indicated that the chance of a completely correct response was improved by approximately 30% with the use of spatialization.

The idea for using spatial audio to enhance the situational awareness of local controllers came about in response to problems observed in the operational environment. In recent years, a number of near midair collisions have shed light on the increased likelihood of mishaps that are partly attributable to traffic density. In air traffic control operations, situational awareness of a local controller at an airfield is critical to prevention of catastrophic midair collisions. We reasoned that spatialized audio technology has the potential to reduce or eliminate temporary losses of situational awareness. A scenario to exemplify typical airfield operations at Camp Pendleton was written using java-based computer code. A virtual tower environment was created with a head-mounted video display, inertial head tracker, and a spatialized audio server. Participants in the study were obtained from the Army, Navy, and Marine Corp's aviation communities. Results indicated that participants located aircraft more rapidly and accurately using spatialized

audio icons than with visual search and radio calls alone. Participants were able to accurately locate and identify aircraft the pattern around "Virtual Camp Pendleton" approximately 900 milliseconds faster using spatialized auditory icons. Realizing that there may be a high aircraft density in the pattern, this is a significant time reduction, as the time savings would be cumulative.

2. Videogame Interface Design

We felt that videogame interfaces were interesting for use in advanced display design for a number of reasons. First, we postulated that videogame interfaces have a fast evolutionary design cycle. Networked videogames require players to track multi-dimensional data in more-or-less real time. Interfaces which are poorly designed or are difficult to use will result in unpopular games or user complaints. So, each generation of videogames will improve upon the deficiencies found in the last generation. Contrast this to military displays which have an extraordinarily slow evolutionary cycle. Many military displays are dominated by text or are essentially paper maps applied to a display screen.

In order to look at the evolution of displays in videogames and determine possible display techniques used in videogames which could be applied to advanced military displays, we first had to do a systematic analysis of videogame interfaces. To do this, we developed a Game Evaluation Form to aid in the expeditious evaluation of each of 29 games evaluated. One of the analysis criterions was to see how usable the interface was during the first hour of the evaluation. This demonstrated the natural usability of the interface and provided evidence for features and drawbacks in molding a prototype interface. The evaluation form focused on the aspects of the interface that could be integrated into a possible C2 interface prototype. We evaluated:

a. Mini-Map

The "mini-map" is a simple graphic tool to provide a user orientation between the media and the virtual environment. It may provide an array of information, but the primary functions are expedient navigation to distant locales in the battle space, orientation in the battle space, and a high level display of the complete picture in a useable resolution. The mini-map evaluation was the most in-depth, as it is the most obvious tool for a real world system. The challenge lay in developing a tool with realistic inputs based on the current and emerging technological capabilities of the military.

b. Interface Integration

The manner in which an interface is interwoven into the overall tool greatly affects how a user can interact with it; the approximate screen space that is occupied, the separation and organization of the interface tools, and accessibility of functions all contribute to the performance of the user.

c. Navigation

The ability of the user to efficiently put the area of interest in the main viewing area for observation and subsequent decision-making is a key feature of the interface. How does a user navigate the battle space and how is the user's egocentric representation handled? Most games cast the user as a third person demigod that has no real identity in the virtual world. In reality, a battle commander will have a location and characterization in the battle space, even if it is but a command center graphic. This unique condition was handled by some games, and their solution was of particular note.

d. Communication

The lifeblood of any commander is communication. The bulk of the game evaluation sought to explain how games enable a user to efficiently process data from the multitude of communication avenues. Particular efforts to combine inputs from diverse sources and efforts to improve situational awareness through multi-modal inputs were sought.

e. Symbology

Because there is a limited amount of screen space to display pertinent information to a commander, many objects are graphically abstracted. This abstraction is backed by an inexact science one could term "symbology". A level of detail and recognizability is required to ensure usability while a level of simplification is required for unobtrusive synthesis into the system. Many examples in our analysis of real world C2 systems demonstrated the need for improvements in graphical representations of objects.

Results indicated that the main viewing area of most games is tending toward a true three dimensional view with variable perspectives. There is more to this trend than entertainment and showing off fancy new graphics technologies. It allows the user to see the terrain and determine how the terrain can influence their forces. It also allows the user to get the best view of the current battle.

At the same time, the amount of the screen devoted to the interface is tending to get smaller and smaller. The more area the user can see on the main viewing screen, the greater their situational awareness and the better they are able to control their forces. However, the controls are still available and can be quickly accessed when needed.

The location of the mini-map is fairly evenly split between the top and the bottom of the screen, but shows a strong tendency to be on the right hand side of the screen. This is most likely due to the majority of users being right handed.

The size of the mini-map has shown fluctuations over time, but its readability has shown a steady decline. This may be due to a change in the purpose of the mini-map. Mini-maps were first introduced as a solution to the problem of slow main map scrolling. Computers and graphics technology were not able to allow the user to move the main view around quickly so the mini-map was used to teleport to a new location. This required a fairly large, readable, mini-map so that you could determine exact locations for movement or viewing.

Now that we have faster, more efficient computers and better graphics technology the need to use the mini-map to overcome a slow main map screen has diminished. The mini-map is used more as a "mouse-pad" that controls the scrolling of the main screen. As more games include variable perspectives it is also being used to help the user keep track of where they are currently oriented. These functions require neither a large, nor detailed mini-map.

This preliminary study has shown interesting trends in the evolution and progression in interface design for networked videogames. Our analysis also indicates that many of these techniques could be used in both current and emerging NCW military systems.